

WATER MARKING IN A DATA INTERVAL GAP

[0001] This application claims the priority of Japanese Application Patent No. 2002-306830, filed on October 22, 2002, and entitled "Storage Device, Program for Controlling Storage Device, Method for Controlling Storage Device and Recording Medium."

BACKGROUND OF THE INVENTION

1. Technical Field

[0002] The present invention relates to a storage device, a program for controlling the storage device, a method for controlling the storage device and a recording medium. Particularly, the present invention relates to a storage device for recording additional data in association with data to be recorded when the data to be recorded is divided into multiple blocks and recorded on a recording medium, a program for controlling the storage device, a method for controlling the storage device and a recording medium.

2. Description of the Related Art

[0003] With a recent increase in demand for distribution of digital data, there have been developed methods for adding data for identifying digital data to the digital data. For example, Japanese Patent Publication No. 2001-518651 discloses a method for incorporating electronic watermarking data into digital data such as audio, video and image data.

[0004] Since the method of incorporating electronic watermarking data into digital data itself changes the original digital data, it is not appropriate to apply this method to digital data that cannot be changed, such as a program of an information processing system or accounting information. In such a case, therefore, a method of adding data to be used for identification of digital data without changing the digital data itself is desirable.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, where:

[0009] **Figure 1** shows a configuration of storage system 10 according to the embodiment of the present invention;

[0010] **Figure 2** shows a configuration of storage device **110a** according to the embodiment of the present invention;

[0011] **Figure 3** shows a writing process flow in storage device **110a** according to the embodiment of the present invention;

[0012] **Figure 4** shows a reading process flow in storage device **110a** according to the embodiment of the present invention;

[0013] **Figure 5** shows a reading process flow in storage device **110a** according to the modified embodiment of the present invention;

[0014] **Figure 6** shows data recording formats for recording medium **200** according to the embodiment of the present invention, in which (a) shows a case where additional data has been recorded multiple times, (b) shows a case where the recording position of second record data **630b** has been changed, and (c) shows a case where recording position change information is used; and

[0015] **Figure 7** shows a configuration of information processing device **100** according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] The present invention is now described below with reference to its embodiments. It should be noted, however, that the embodiments do not limit the scope of the invention defined by the claims, and all the combinations of features described in the embodiments are not necessarily essential for the invention to solve the problem.

[0017] **Figure 1** shows a configuration of a storage system **10** according to the embodiment. The storage system **10** according to the embodiment is provided with an information processing device **100** and storage devices **110a** and **110b**.

[0018] The information processing device **100** is connected to the storage devices **110a** and **110b** and accesses the storage devices **110a** and **110b** based on a request received from another information processing device connected via the network. In other words, when a data write request is received from another information processing device, the information processing device **100** sends the data to be written to a storage device **110** to which the data should be written and causes the storage device **100** to perform a writing process. On the contrary, when a data read request is received from another information processing device, the information processing device **100** causes a storage device **110** from which the data should be read to perform a reading process, and sends the read data to the information processing device requesting the data. Also, the information processing device **100** performs a copy operation between recording media of the storage devices **110a** and **110b** based on, for example, an instruction from a user of the storage system **10**.

[0019] **Figure 2** shows a configuration of a storage device **110a** according to the embodiment. When dividing data to be written into multiple blocks and recording them on a recorded medium, the storage device **110a** according to the embodiment incorporates additional data as recording positions of the respective blocks. Thus, the additional data can be recorded on the recording medium without changing the data to be written.

[0020] The storage device **110a** is provided with a write-control section **210** and a read-control section **220** and uses a recording medium **200**. Since the configuration of the storage device **110b** is almost the same as that of the storage device **110a**, the description thereof is omitted here.

[0021] The recording medium **200** records multiple blocks produced by dividing data to be written. A magnetic tape conforming to the LTO (Linear Tape-Open) standard, for example, is used as the recording medium **200** according to the embodiment. Alternatively, other recording media, such as a magnetic disk, an optical disk, a magneto-optical disk, and a semiconductor memory, may be used as the recording medium **200**.

[0022] The write-control section **210** receives a write request and data to be written from the information processing device **100** and writes the data to be written to the recording medium **200**. The write-control section **210** comprises an additional data storing section **230**, a recording position determining section **235** and a block writing section **240**.

[0023] The additional data storing section **230** stores additional data to be recorded on the recording medium **200** in association with the data to be written. In this case, the additional data may be electronic watermarking data including device identification information such as a serial number of the storage device **110a**, date and time of writing, identification information for the data to be written which is specified by a user of the storage device **110a**, a password for releasing a read restriction on the data to be written, and the like, which is added to identify the data to be written. Alternatively, the additional data may include various information, such as fault information for identifying a fault caused in writing onto the recording medium **200**, which is usually concealed from the user of the storage device **110a**.

[0024] The recording position determining section **235** determines recording positions on the recording medium **200** where the blocks produced by dividing the data to be written are respectively written, based on the additional data acquired from the additional data storing section **230**. By dividing the data to be written into multiple blocks and causing the recording position determining section **235** to specify recording positions where the respective blocks are

written, the block writing section **240** writes the respective blocks to the recording positions on the recording medium that have been determined by the recording position determining section **235**.

[0025] The read-control section **220** receives a read request from the information processing device **100** and reads data to be read, which has been divided into multiple blocks and recorded on the recording medium **200**. The read-control section **220** comprises a block reading section **250**, a recording position acquiring section **255**, an additional data extracting section **260** and a block readout inhibiting section **265**.

[0026] The block reading section **250** reads multiple blocks from the recording medium **200**. The recording position acquiring section **255** acquires recording positions on the recording medium **200** where the respective blocks are recorded. The recording position acquiring section **255** then composes data to be read by putting together the read blocks, and sends it to the information processing device **100**. In this case, the recording position acquiring section **255** may acquire from the block reading section **250** the recording positions specified by the block reading section **250** to read the respective blocks. The additional data extracting section **260** extracts additional data recorded on the recording medium **200** in association with the data to be read, from the recording positions corresponding to the blocks, respectively, which have been acquired by the recording position acquiring section **255**. The additional data extracting section **260** sends the additional data to the information processing device **100** if it has been set to do so.

[0027] In the case where the additional data is electronic watermarking data, the block readout inhibiting section **265** inhibits the blocks from being read by the block reading section **250** if the additional data extracted by the additional data extracting section **260** does not correspond to electronic watermarking data to be recorded on the recording medium **200** in association with data to be written in a writing process. The block readout inhibiting section **265** according to the embodiment may use additional data stored in the additional data storing section **230** as electronic watermarking data to be recorded on the recording medium **200** in association with data to be written in a writing process. In this case, the additional data stored in the additional data storing section **230** may be data stored in advance, such as device identification

information of the storage device **110a**, or data specified through the information processing device **100** when the recording medium **200** is read.

[0028] The following functions can be provided by the storage device **110a** described above.

(1) Case where electronic watermarking data is recorded as additional data:

[0029] The storage device **110a** can embed electronic watermarking data for identifying data to be written in a recording medium **200** as recording positions of the respective blocks produced by dividing the data to be written. Accordingly, identification information of a storage device which has performed writing to the recording medium **200**, time and date of the writing, and the user who has requested the writing, for example, can be embedded in the recording medium **200** as electronic watermarking data, and it is possible to prove that the recording medium **200** has been completely copied illegally, based on such information.

[0030] In some storage devices, information on recording positions of the respective blocks is lost when the recording medium **200** is copied. In this case, it is possible to prove that a recording medium is a copied one by detecting that the same data as that on the recording medium **200** is recorded thereon and electronic watermarking data has been lost.

[0031] Furthermore, by inhibiting multiple blocks from being read by the block reading section **250** if recording positions of the blocks read from the recording medium **200** in a reading process of the recording medium **250** do not correspond to valid electronic watermarking data, it is possible to prevent the recording medium **200**, from which the electronic watermarking data has been lost due to illegal copying, from being read.

(2) Case where data other than electronic watermarking data is recorded as additional data:

[0032] In the storage device **110a**, it is possible to record data, which usually cannot be read by a user of the storage system **10**, on a recording medium **200** as additional data. For example, in the storage device **110a**, fault information for identifying a fault caused during writing to a

recording medium is stored in the additional data storing section **230** and is written as additional data to a recording medium **200** together with data to be written. This allows a user or a manufacturer of the storage system **10** to identify a fault caused during writing by acquiring the additional data from the recording medium **200** in case of any error caused in writing to the recording medium **200**.

[0033] **Figure 3** shows a writing process flow in the storage device **110a** according to the embodiment. When a write request is received from the information processing device **100**, the storage device **110a** prepares additional data to be recorded on the recording medium **200** in association with data to be written and stores it in the additional data storing section **230** (**S300**). In this case, the additional data may be specified by a user of the storage system **10** and stored in the additional data storing section **230** via the information processing device **100**, or it may be generated through conversion of the data to be written based on a predetermined algorithm, or it may be set in the additional data storing section **230** in advance when the storage device **110a** is manufactured.

[0034] Next, the block writing section **240** receives data to be written from the information processing device **100** and divides it into multiple blocks (**S310**). The recording position determining section **235** then determines recording positions on the recording medium **200** where the blocks divided by the block writing section **240** are respectively written (**S320**). The block writing section **240** writes the respective blocks to the recording positions on the recording medium determined by the recording position determining section **235** (**S330**).

[0035] **Figure 4** shows a reading process flow in the storage device **110a** according to the embodiment. Particularly, **Figure 4** shows a reading process in the case where portions of electronic watermarking data, for example, one bit data values are recorded on the respective recording positions of the blocks.

[0036] When a read request is received from the information processing device **100**, the block reading section **250** sequentially reads each block (**S400**). Next, the recording position acquiring section **255** sequentially acquires a recording position of each block read by the block

reading section **250** (**S410**). The additional data extracting section **260** then sequentially extracts additional data recorded on the recording medium **200** in association with the data to be read from each of the recording positions of the blocks that have been acquired by the recording position acquiring section **255** (**S420**).

[0037] If the recording position of one block acquired by the recording position acquiring section **255** does not correspond to the electronic watermarking data recorded on the recording medium **200** in association with the data to be written in the writing process, the block readout inhibiting section **265** determines that the extracted additional data is invalid (**S430**). More particularly, if the additional data extracted by the additional data extracting section **260** does not match the corresponding portion of the electronic watermarking data stored in the additional data storing section **230**, then the block readout inhibiting section **265** determines that the additional data is invalid. If the additional data is determined to be invalid, the block readout inhibiting section **265** inhibits reading of the block that has been determined at **S430** to be stored in a recording position that does not correspond to the electronic watermarking data, and subsequent blocks (**S450**). In response to this, the block reading section **250** stops reading of the blocks starting from that block. In this case, the block reading section **250** may read some blocks starting from that block before reading is stopped because the stop of reading is late, for example.

[0038] On the contrary, if the additional data is determined to be valid at **S430**, then the process from **S400** to **S430** is repeated until reading of the blocks is completed (**S440**).

[0039] Through the reading process described above, the storage device **110a** can sequentially extract the additional data that has been added in association with the data to be written in the writing process. The storage device **110a** can stop reading of the data from the recording medium **200** when the extracted additional data does not correspond to the electronic watermarking data.

[0040] **Figure 5** shows a reading process flow in the storage device **110a** according to a modified embodiment.

[0041] When a recording medium **200** is mounted on the storage device **110a**, the recording position acquiring section **255** scans multiple blocks included in the data written on the recording medium **200** to acquire multiple recording positions corresponding to the respective blocks (**S500**). Next, the additional data extracting section **260** extracts additional data recorded on the recording medium **200** in association with the data to be read, from the recording positions that have been acquired by the recording position acquiring section **255** (**S510**). When a read request is received from the information processing device **100**, the block readout inhibiting section **265** determines that the additional data is invalid if the recording positions do not correspond to the electronic watermarking data which was recorded in association with the data to be written when the data was written to the recording medium **200** in the writing process (**S520**). If the additional data is determined to be invalid, the block readout inhibiting section **265** inhibits the blocks from being read by the block reading section **250**. On the contrary, if the additional data is determined to be valid, the block reading section **250** reads the blocks and sends them to the information processing device **100**.

[0042] According to the modified embodiment described above, the storage device **110a** can determine whether or not the additional data corresponding to the data recorded on the recording medium **200** is valid electronic watermarking data when the recording medium **200** is mounted thereon. The storage device **110a** can then inhibit data from being read from the recording medium **200** when the additional data is not correct electronic watermarking data.

[0043] **Figure 6** shows a data recording format in the case where the recording medium **200** is a magnetic tape in accordance with the LTO standard. The reference numerals **600a** to **600c**, **630a** to **630c**, and **690** denote block recording areas for recording the respective blocks obtained by dividing the data to be written. First attribute data **610a** to **610c**, second attribute data **640a** to **640c**, and Nth attribute data **670** are block attributes written in association with the first record data **600a** to **600c**, the second record data **630a** to **630c**, and the Nth record data **660**, respectively. First gaps **620a** to **620c**, second gaps **650a** to **650c**, and an Nth gap **680** are block gaps each of which is to be provided between continuous blocks in the writing process.

[0044] **Figure 6(a)** shows a recording format in the case where the same additional data is recorded multiple times. In the writing process, by determining sizes of the block gaps such as the first gap **620a**, the second gap **650a** and the Nth gap **680**, based on additional data stored in the additional data storing section **230**, the recording position acquiring section **255** determines the recording positions of the second record data **630a**, the Nth record data **660** and the Nth gap **680**. For example, if the first data value of the additional data is "d1", then the length of the first gap **620a** is set to 11, and if the first data value of the additional data is "d2", then the length of the gap **620a** is set to 12, and so forth. Thus, the length of a block gap is determined based on each data value of the additional data. When the data value is a particular value such as 0, the corresponding length of a block gap may be set to 0. Thus, the recording medium **200** includes multiple block recording areas for recording the respective blocks obtained by dividing the data to be recorded, such as the first record data **600a**, the second record data **630a**, the Nth record data **660** and the (N+1)th record data **690**, and the recording positions on the recording medium **200** for the block recording areas are determined based on the additional data recorded on the recording medium **200** in association with the data to be recorded. More particularly, the recording positions are determined by determining the sizes of the respective block gaps provided between continuous block storage areas based on the additional data.

[0045] In **Figure 6(a)**, the recording position determining section **235** groups the blocks obtained by dividing the data to be written into multiple groups and determines recording positions on the recording medium where the respective blocks included in each of the groups should be written, based on the additional data. That is, in **Figure 6(a)**, the blocks obtained by dividing the data to be written are grouped into a group including record data from the first record data **600a** to the (N-1)th record data and a group including the Nth record data **660** and subsequent record data, and the additional data is recorded in each block gap in each group. Accordingly, in the storage device **110a**, the additional data can be repeatedly written multiple times in association with the data to be written, so that correct additional data can be read out even when any fault is caused in one of the additional data.

[0046] **Figure 6(b)** shows a recording format in the case where the recording position of the second record data **630b** has been changed. In the recording format of **Figure 6(b)**, when the

respective blocks are written, the recording position determining section **235** determines multiple recording positions on the recording medium **200** where the blocks should be written, respectively, based on the additional data. The block writing section **240** then writes a block on one recording position selected from the multiple recording positions where the block should be written. That is, in the recording format of **Figure 6(b)**, when the second record data **630b** is written, the recording position determining section **235** determines multiple lengths such as $\ell 1$, $\ell 1'$ and $\ell 1''$ for the first gap **620b** which is an example of a recording position on the recording medium **200** where the second record data **630b** should be written. The block writing section **240** then selects one writable recording position, for example, among those recording positions and writes the block there. Accordingly, the storage device **110a** can select a different recording position for writing in case of any fault caused in writing to the recording position determined by the recording position determining section **235**.

[0047] **Figure 6(c)** shows a recording format in the case where recording position change information is used, which indicates that a recording position determined based on the additional data has been changed. In **Figure 6(c)**, when it is impossible to write one block to a recording position on the recording medium **200** where that block should be written, the block writing section **240** writes that block and recording position change information indicating that the recording position of that block has been changed to another recording position different from the recording position where that block should be written. That is, in **Figure 6(c)**, the block writing section **240** cannot set the length $\ell 1$ for the first gap **620c** where the second record data **630c** should be written, because of a fault caused in the writing process, for example. In this case, the block writing section **240** writes the second record data **630c** with a value different from the value determined based on the additional data set for the length of the first gap **620c**, and writes recording position change information "skipped", which indicates that the recording position of the second record data **630c** has been changed, on the second attribute data **640c**. Thus, in the reading process, as a result of reading the recording position change information "skipped" recorded in the second attribute data **640c**, the recording position acquiring section **255** can recognize that the record position of the first gap **620c** is invalid and extract additional data from the second gap **650c** and subsequent gaps.

[0048] **Figure 7** shows an example of a hardware configuration of the information processing device **100** according to the embodiment. The information processing device **100** according to the embodiment comprises a CPU/peripheral part including a CPU **700**, a RAM **720**, a graphic controller **775** and a display device **780**, which are mutually connected via a host controller **782**; an input/output part including a communication interface **730**, a hard disk drive **740**, a CD-ROM drive **760** and a storage device interface **785**, which are connected to the host controller **782** via an input/output controller **784**; and a legacy input/output part including a ROM **710**, a flexible disk drive **750** and an input/output chip **770**, which are connected to the input/output controller **784**.

[0049] The host controller **782** connects the RAM **720** with the CPU **700** and the graphic controller **775** which access the RAM **720** at a high transmission rate. The CPU **700** operates based on programs stored in the ROM **710** and the RAM **720** to control each part. The graphic controller **775** acquires image data that is generated in a frame buffer provided within the RAM **720** by the CPU **700** to display it on the display device **780**. Alternatively, the graphic controller **775** may include therein a frame buffer for storing image data generated by the CPU **700**.

[0050] The input/output controller **784** connects the host controller **782** with the communication interface **730**, the hard disk drive **740**, the CD-ROM drive **760** and the storage device interface **785**, which are relatively high speed input/output devices. The communication interface **730** communicates with other devices via a network. The hard disk drive **740** stores programs and data to be used by the information processing device **100**. The CD-ROM drive **760** reads a program or data from a CD-ROM **795** and provides it for the storage device interface **785** via the RAM **720** and the input/output controller **784**. The input/output controller **784** accesses the storage devices **110a** and **110b** based on a request received by the communication interface **730** from other information processing devices connected via the network.

[0051] The ROM **710** and relatively low speed input/output devices, such as the flexible disk drive **750** and the input/output chip **770**, are connected to the input/output controller **784**. The ROM **710** stores a boot program to be executed by the CPU **700** at a startup time of the information processing device **100**, and hardware dependent programs for the information

processing device **100**. The flexible disk drive **750** reads a program or data from a flexible disk **790** and provides it to the storage device interface **785** via the RAM **720** and the input/output controller **784**. The input/output chip **770** connects the flexible disk **790** and also connects various input/output devices via, for example, a parallel port, a serial port, a keyboard port, and a mouse port.

[0052] A program to be provided by a user to the storage device **110a** or **110b** via the storage device interface **785** is stored in a recording medium such as the flexible disk **790**, the CD-ROM **795**, or an IC card. The program is read from the recording medium, installed in the storage device **110a** or **110b** via the input/output controller **784** and the storage device interface **785**, and executed in the storage device **110a** or **110b**. Alternatively, each of the storage devices **110a** and **110b** may further include a flexible disk drive, a CD-ROM drive or an IC card reader so that a program is directly read from a recording medium for execution or read from the recording medium **200** for installation.

[0053] Programs to be installed and executed in the storage devices **110a** and **110b** include an additional data storing module, a recording position determining module, a block writing module, a block reading module, a recording position acquiring module, an additional data extracting module and a block readout inhibiting module. These programs or modules cause each of the storage devices **110a** and **110b** to function as an additional data storing section **230**, a recording position determining section **235**, a block writing section **240**, a block reading section **250**, a recording position acquiring section **255**, an additional data extracting section **260** and a block readout inhibiting section **265**.

[0054] The programs or modules described above may be stored in an external recording medium. As the recording medium, an optical recording medium such as a DVD or a PD, a magneto-optical recording medium such as an MD, a tape medium, a semiconductor memory such as an IC card, or other like medium may be used in addition to the flexible disk **790** and the CD-ROM **795**. Furthermore, by using a storage device such as a hard disk or a RAM provided in a server system connected to a dedicated communication network or the Internet as a

recording medium, a program may be provided to the storage device **110a** or **110b** via the network.

[0055] The information processing device **100** may request the storage device **110a** to read the data to be read and corresponding additional data from the recording medium **200** mounted on the storage device **110a** and request the storage device **110b** to write the read data and additional data on the recording medium **200** mounted on the storage device **110b**. Thus, the information processing device **100** can cause the additional data embedded in recording positions of multiple blocks recorded on the recording medium **200**, which is mounted on the storage device **110a**, to be recorded on the recording medium **200** which is mounted on the storage device **110b**.

[0056] In this case, the information processing device **100** may change a part of the additional data received from the storage device **110a** to cause it to be recorded by the storage device **110b**. For example, the information processing device **100** may add to at least a part of additional data received from the storage device **110a**, information indicating that the data has been copied, sends the additional data to the storage device **110b** and causes it to be recorded on the recording medium **200** mounted on the storage device **110b**. Furthermore, the information processing device **100** may increment the number of times of copying indicated by copy frequency information included in at least a part of additional data received from the storage device **110a**, sends the additional data to the storage device **110b**, and causes it to be recorded on the recording medium **200** mounted on the storage device **110b**. Thus, the information processing device **100** can cause the information indicating that data has been copied or the information indicating the number of times of copying, to be recorded on the recording medium **200** mounted on the storage device **110b**.

[0057] While the present invention has been described using the embodiments, the technical scope of the present invention is not limited to the scope described in the above embodiments. Various modifications or improvements may be made to the embodiments described above. It is apparent from the appended claims that the embodiments to which such modifications or

improvements have been made should also be included in the technical scope of the present invention.

[0058] For example, if the recording medium **200** is a magnetic disk, an optical disk, or a magneto-optical disk, the recording position determining section **235** may determine recording positions such as tracks or sectors where the respective blocks are to be written, based on the additional data.

[0059] As is apparent from the above description, according to the present invention, it is possible to store digital data in a storage device with data, which is to be recorded in association with the digital data, added to the digital data without changing the original digital data to be written.